

Review of the family Serranidae (Perciformes) from the Canary Islands (eastern-central Atlantic), with the first records of *Serranus hepatus* and *Epinephelus aeneus*

by

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Abstract. – This paper is an updated account of the Serranidae (groupers and sea basses) from the Canary Islands (eastern-central Atlantic). In this region this family is represented by 16 valid species belonging to six genera: *Serranus*, *Anthias*, *Cephalopholis*, *Epinephelus*, *Mycteroperca*, and *Paranthias*. Their biogeographic patterns and known distribution are provided, and several hypotheses explaining their presence in the Canaries are discussed. Settlement of *Epinephelus costae* is confirmed in Canary waters, where it is subject to regular recreational fishing. Also, the present report first records *Serranus hepatus* and *Epinephelus aeneus* from the Canaries. For each species, biogeographic pattern, temporal establishment process, local fishing uses, and measures for their conservation management are discussed and summarized in a table.

Résumé. – Révision de la famille des Serranidae des îles Canaries (Atlantique centre-est), avec les premiers signalements de *Serranus hepatus* et d'*Epinephelus aeneus*.

Cet article est une liste actualisée des Serranidae (mérours et serrans) présents aux îles Canaries (centre-est de l'Atlantique). Dans cette région, cette famille est représentée par 16 espèces valides appartenant à six genres : *Serranus*, *Anthias*, *Cephalopholis*, *Epinephelus*, *Mycteroperca* et *Paranthias*. Leurs affinités biogéographiques et leurs distributions sont données, et quelques hypothèses expliquant leurs présences dans les eaux des Canaries sont discutées. La colonisation d'*Epinephelus costae* est confirmée dans les eaux des Canaries où il fait l'objet d'une pêche de loisir régulière. En outre, *Serranus hepatus* et *Epinephelus aeneus* sont signalés pour la première fois aux îles Canaries. Pour chaque espèce, le profil biogéographique, le processus temporel d'établissement, les utilisations locales de la pêche et quelques mesures de gestion et de conservation sont discutées et résumées dans un tableau.

INTRODUCTION

Except for a few freshwater species, serranids are marine (mostly benthic) fishes of tropical and warm-temperate seas, ranging from shallow coastal waters to depths of 600 m. The great majority inhabits depths less than 200 m (Craig *et al.*, 2011; Heemstra and Anderson, 2016; Nelson *et al.*, 2016).

Although the systematics of the Serranidae is still in a state of flux (Quigley, 2015), and the genera *Epinephelus*, *Mycteroperca* and *Cephalopholis* are considered by some authors (Smith and Craig, 2007; Craig *et al.*, 2011; Laudredou *et al.*, 2013; Ma and Craig, 2018) to belong to the family Epinephelidae, not Serranidae, we follow their classical (Nelson *et al.*, 2016; Fricke *et al.*, 2020a; Froese and Pauly, 2020; Parenti and Randall, 2020) arrangement within the Serranidae *sensu lato*. Groupers, also called sea basses and fairy basslets, are distributed worldwide and represented by 75 genera and at least 583 species (Fricke *et al.*, 2020b), 67 of which were described in the last ten years. However, only 579 species and 72 genera appear in Parenti and Ran-

dall (2020). Of these, 13 genera and 33 species are found in the eastern-central Atlantic Ocean (Heemstra and Anderson, 2016; Froese and Pauly, 2020).

An annotated list of Serranidae occurring around the Canary Islands was published by Brito (1991) and Brito *et al.* (2002). Recently, Falcón *et al.* (2018) reported on three new records of tropical serranids: *Epinephelus adscensionis* (Osbeck, 1765), *Epinephelus fasciatus* (Forsskål, 1775) and *Mycteroperca tigris* (Valenciennes, 1833). Additionally, the serranid species known in the Canaries were included in two recent checklists prepared by Báez *et al.* (2019), the occurrence of these three species is considered as to be confirmed) and by Freitas *et al.* (2019, excluding these three species).

The Spanish Institute of Oceanography (IEO) carried out a series of fishery monitoring surveys in the waters surrounding the island of Tenerife, between 2015 and 2020. Fish specimens thus observed or collected were studied by the authors, and several specimens appeared to belong to a serranid species not regularly occurring in the Canaries.

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With this background, the aims of the present paper are to: (1) update the inventory of the serranid species occurring in Canary Islands waters, analysing their biogeographic patterns and hypothesizing about their presence in the area; (2) confirm the settlement of *Epinephelus costae* (Steindachner, 1878) –already gaining commercial interest in this archipelago; and (3) record *Serranus hepatus* (Linnaeus, 1758) – first documented record – and *Epinephelus aeneus* (Geoffroy Saint-Hilaire, 1817) for the first time from the Canaries.

MATERIAL AND METHODS

This study covers all valid species of Serranidae *sensu lato* occurring around the volcanic archipelago of the Canary Islands (eastern-central Atlantic). The study area is bounded by the 30°N and 27°N parallels, the 19°W meridian and, in the Canaries-Africa channel, the 13°W meridian (Fig. 1).

To verify first records and subsequent new records for each species in the area, old ichthyological references (including the works by Valenciennes (1837-1844), Günther *et al.* (1859), Steindachner (1865, 1867, 1891, 1898), Viera y Clavijo (1868 [1982]), Vinciguerra (1883, 1890, 1893), Jordan and Gunn (1899), Cadenat (1935), Fowler (1936), Lozano y Rey (1952), Santaella *et al.* (1975), Dooley *et al.* (1985), Pizarro (1985), among others) prior to Brito (1991), as well as recent references (González *et al.* (2012), Triay-Portella *et al.* (2015), Pajuelo *et al.* (2016), Falcón *et al.* (2018), Freitas *et al.* (2019), among others) posterior to Brito *et al.* (2002) were checked. This huge and valuable information was summarized for each species in a classical

format. Abbreviations include: Canaries (C), El Hierro (EH), Fuerteventura (F), Gran Canaria (GC), La Gomera (LG), La Graciosa (GR), La Palma (LP), Lanzarote (L) and Tenerife (T).

The taxonomic nomenclature of the taxa involved follows FishBase (Froese and Pauly, 2020) and Eschmeyer's Catalog of Fishes (Fricke *et al.*, 2020a). Both standard and ichthyological meristic/morphometric measurements (in mm) were made following Hubbs and Lagler (1958).

Voucher specimens were deposited in the marine fauna collections (CFM-IEOCA) of the 'Centro Oceanográfico de Canarias' (Casañas Machín and Pascual Alayón, 2020) (belonging to the Spanish Institute of Oceanography, IEO) hosted by GBIF-Spain (<https://www.gbif.org/dataset/6d6e8d0a-de6f-4553-8d40-c9465c3fe10e>). The present work follows the best practice approach to prevent unverified and unverifiable "first records" as proposed by Bello *et al.* (2014).

The citation of non-native species (*i.e.* introduction, migration or range extension) are classified into three categories according to driving forces: "established" – with at least three records, spread over time and space, known for the region (Zenetos *et al.*, 2005; Golani *et al.*, 2017); "first record" – when at least one individual from an identified species is recorded for the first time in the area (Iglésias *et al.*, 2019); and "new records" – additional records whose observation is posterior to the "first record" (Iglésias *et al.*, 2019).

When available, separate data on the 2014-2019 time-series of landings were taken from the official website of the department for fisheries of the Canary Government (<http://>

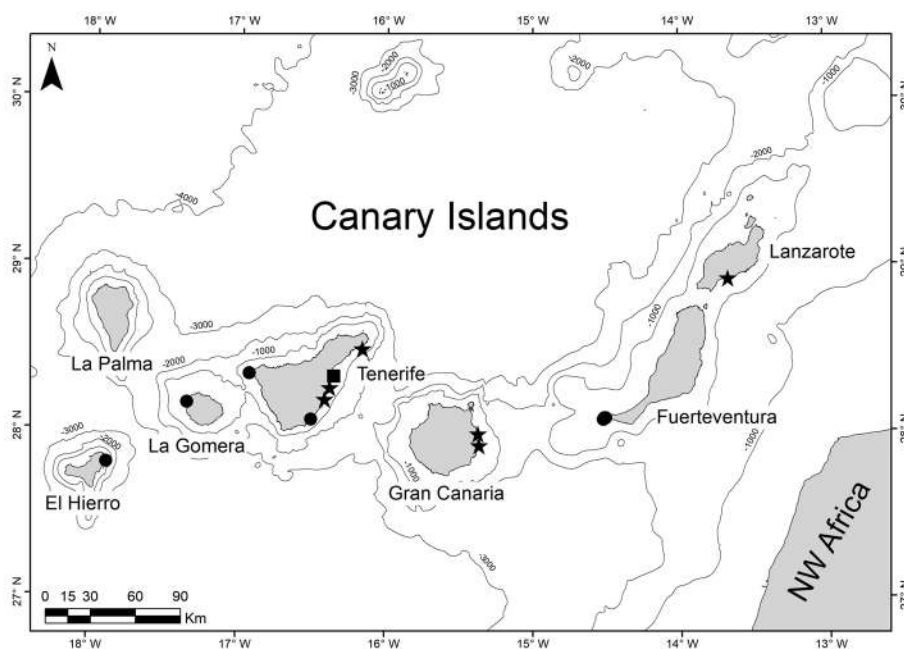


Figure 1. – The Canary Islands. Collection and sighting locations: (★) *Serranus hepatus*; (■) *Epinephelus aeneus*; (●) *Epinephelus costae* (map adapted from BlueChart Atlantic v9.5).

www.gobiernodecanarias.org/agg/sgt/temas/estadistica/pesca/index.html).

RESULTS

Annotated list of Serranidae from the Canary Islands

Subfamily Serraninae

Serranus atricauda Günther, 1874 – Blacktail comber

Serranus cabrilla (part): Günther, 1859: 282 (T).

Serranus atricauda: Günther, 1874: 230 (T); Steindachner, 1891: 351 (GC, L, F); Cadenat, 1935: 390-391 (C); Santaella *et al.*, 1975: 355 (T, GC, LP); Brito, 1991: 104 (C); Dooley *et al.*, 1985: 15 (GC, C); Pizarro, 1985: 82 (F); González-Jiménez *et al.*, 1994: 83 (C); Franquet and Brito, 1995: 67 (C); Brito *et al.*, 2002: 217, 234 (C); González *et al.*, 2012: 138-139 (C); Báez *et al.*, 2019: suppl. tab. (C); Freitas *et al.*, 2019: suppl. tab. S3 (C).

Paracentropristis atricauda: Fowler, 1936: 769-770 (L, GC, T).

An eastern Atlantic warm-temperate species; distributed from France (Béarez *et al.*, 2017) to Morocco (Cadenat, 1935; Collignon, 1973 – rare) and southwards to Guinea-Bissau, including the Azores, Madeira, Selvagens, Canary and Cabo Verde Islands; also known from the Mediterranean (Morocco and Algeria) (Heemstra and Anderson, 2016; Freitas *et al.*, 2019; Froese and Pauly, 2020).

It is a very common species native to the Canary Islands; spread throughout the archipelago from 3 to 328 m depth, mainly to about 150 m (Brito *et al.*, 2002). Reported maximum size: to 50 cm TL and 1.3 kg (González *et al.*, 2012), but up to 35 cm in Heemstra and Anderson (2016); common to 35 cm TL. Spanish vernacular names: cabrilla negra; cabrilla de tierra; cabrilla ruana; cabrilla rubia. In the region, it is an important fishery resource exploited all year round by domestic small-scale fisheries with hook-and-line, traps and trammel nets (González *et al.*, 2020). A decreasing trend in their mean sizes and landings was observed by the authors over the 2014-2019 period, with 27.7 t in 2014 and 15.9 t in 2019. This resource is also subject to intense recreational fishing activity.

Serranus cabrilla (Linnaeus, 1758) – Comber

Serranus cabrilla: Valenciennes, 1842: 7 (C); Steindachner, 1865: 399 (T), 1867: 611 (T); Vinciguerra, 1883: 609 (L), 1890: 469 (GC), 1893: 303 (GC); Cadenat, 1935: 386-387 (C); Santaella *et al.*, 1975: 21 (LP); Brito, 1991: 104 (C); Dooley *et al.*, 1985: 15 (C); Pizarro, 1985: 82 (F); González-Jiménez *et al.*, 1994: 84 (C); Franquet and Brito, 1995: 67 (C); Brito *et al.*, 2002: 217, 235 (C); González *et al.*, 2012: 140-141 (C); Báez *et al.*, 2019: suppl. tab. (C); Freitas *et al.*, 2019: suppl. tab. S3 (C).

Perca cabrilla: Viera y Clavijo, 1868 (1982): 92 (C).

Serranus (Pseudoserranus) cabrilla: Steindachner, 1891: 349-350 (T).

Paracentropristis cabrilla: Fowler, 1936: 768-769 (T, GC).

An eastern Atlantic warm-temperate species, distributed from the English Channel to Morocco (Cadenat, 1935; Collignon, 1973 – very common) and southwards to Cape of Good Hope (and spilling over to Natal), South Africa, including the Azores, Madeira, Canary and Cabo Verde Islands; also known from the Mediterranean and western Black Sea (Heemstra and Anderson, 2016; Freitas *et al.*, 2019; Froese and Pauly, 2020). It was also reported from the Red Sea (immigrant from the Mediterranean Sea) (Parenti and Randall, 2020). However, South African records (South Africa north to KwaZulu-Natal, Fricke *et al.*, 2020b) of this species appear to be misidentifications of *Serranus knysnaensis* Gilchrist, 1904, which is endemic to southern Africa (Heemstra and Anderson, 2016).

It is a common native species in the Canary Islands, spread throughout the archipelago, but absent from El Hierro – the westernmost island in the archipelago, with warmer littoral waters. It inhabits from 5 to 350 m depth, mainly down to 50 m (Brito *et al.*, 2002). Reported maximum size: to 45 cm TL and 1.0 kg (González *et al.*, 2012); common to 28 cm TL. Spanish vernacular names: cabrilla reina; cabrilla de fuera; cabrilla melera. Exploitation by local artisanal fisheries: as in the previous species (González *et al.*, 2020). Its landings seem to have stabilized near 20 tons a year (t/y) in the period of 2014-2019. This resource is also subject to some recreational fishing activity.

Serranus hepatus (Linnaeus, 1758) – Brown comber

Paracentropristis hepatus: Fowler, 1936: 765-766 (C); Lozano y Rey, 1952: 82 (C).

Serranus hepatus: Tortonese, 1979: 356 (C), 1986: 791 (C); C.L. Smith, 1981: vol. 4 (C), 1990: 705; Dooley *et al.*, 1985: 15 (GC); Parenti and Randall, 2020: 125 (C).

An Atlanto-Mediterranean species, distributed throughout the western and eastern Mediterranean, and in the Eastern Atlantic from Portugal to Morocco (Cadenat, 1935; Collignon, 1973) and southwards to Senegal (Heemstra and Anderson, 2016; Froese and Pauly, 2020). The report of this species from the Canaries by Dooley *et al.* (1985) was considered as a misidentification (Brito *et al.*, 2002). This is the first documented record for *S. hepatus* in Canary Islands waters; see Discussion.

Material examined. – GBIF-CFM-IEOCA 1198 and 1199, two specimens, 87.6 mm and 86.0 mm total length (TL) (Fig. 2), off Roque de Fasnía, eastern Tenerife, 28°13'04"N 16°24'11"W, 120 m depth, F/V *Mencey*, 3 Mar. 2020, bottom traps. GBIF-CFM-IEOCA 1200, one specimen, 84.4 mm TL, off Punta Prieta, eastern Tenerife,



Figure 2. – *Serranus hepatus* from Tenerife, Canary Islands (GBIF-CFM-IEOCA 1199, 86.0 mm TL, 69.2 mm SL) (Credits: J.F. González-Jiménez, 2020).

28°15'31"N 16°22'46"W, 90 m depth, F/V *Ciclón Uno*, 27 Oct. 2020, bottom trap. Additionally, five unpreserved specimens, 57, 66, 68.5, 72, and 84.5 mm TL, off Playa de Las Gaviotas, eastern Tenerife, 28°29'34"N 16°09'34"W, 140 m depth, F/V *Rosario I*, 12 Nov. 2020, one bottom trap.

Morphology data. – Taken from the three preserved specimens (66.6–71.5 mm standard length, SL). Meristics: Fins formulae, D X+11–12, A III+7, P 15, V I+5, C 15. Gill rakers 7–7+13–14 (total 20–21). Lateral-line (LL) scales 49–50; scales between first-dorsal base and LL 6–7, circum-peduncular scales 21–24. Other diagnostic characters: body depth contained 2.9 to 3.2 times in SL (but 2.5 to 3.0 times in Heemstra and Anderson, 2016). Eye diameter contained 3.2 to 3.6 times in head length.

Additional sightings and remarks. – Both masters of the aforementioned fishing vessels reported frequent catches of *S. hepatus* in the zone, sometimes more than one individual per trap. Also observed and photographed on the eastern coasts of Gran Canaria (off Taliarte, May 2020, a 5 cm individual, 5–6 m depth; off Tufia, Nov. 2020, a 5 cm individual, 6 m depth) and Lanzarote (off Puerto del Carmen, Sep. 2020, a 12 cm individual, 12–13 m depth) (Fig. 3) (A. Telle, professional submarine photographer, pers. comm. 2020).



Figure 3. – *Serranus hepatus* from Lanzarote, Canary Islands (Credits: A. Telle, 2020).

It is a locally rare-to-frequent species of recent occurrence in the Canaries. Reported maximum size: to 12 cm TL.

***Serranus papilionaceus* Valenciennes, 1832** – Moth-winged comber (see remarks)

Serranus papilionaceus: Valenciennes, 1842: 7 (C, L, T); Vella *et al.*, 2021: 111–126 (C).

Serranus scriba var. *papilionaceus*: Vinciguerra, 1890: 469 (GC), 1893: 303 (GC, T).

Serranus scriba: Steindachner, 1867: 609–611 (T); Vinciguerra, 1883: 608 (T, L); Jordan and Gunn, 1899: 341 (C); Cadenat, 1935: 388–390 (C); Brito, 1991: 104 (C); Dooley *et al.*, 1985: 15 (GC); Pizarro, 1985: 83 (F); González-Jiménez *et al.*, 1994: 85 (C); Franquet and Brito, 1995: 67 (C); Brito *et al.*, 2002: 217, 237 (C); González *et al.*, 2012: 142–143 (C); Báez *et al.*, 2019: suppl. tab. (C); Freitas *et al.*, 2019: suppl. tab. S3 (C).

Paracentropristis scriba: Fowler, 1936: 766–768 (L, GC).

This species has been very recently resurrected as a valid *Serranus* species based on its morphology, colour pattern and phylogenetic characteristics (Vella *et al.*, 2021). Therefore, the congeneric species *Serranus scriba* (Linnaeus, 1758) is now restricted to the Mediterranean Sea. To date, *S. papilionaceus* has been reported from the Canary Islands, Morocco (Cadenat, 1935; Collignon, 1973 – common), Mauritania (Cap Blanc, Baie du Levrier), Senegambia (at least off Dakar and Gorée Island, Senegal), Guinea-Bissau (Sanchez, 1991) and southwards to Angola (Valenciennes, 1837–1844; Cadenat, 1935; Vella *et al.*, 2021). Reports of this species from Madeira and the Azores are unsubstantiated (Wirtz *et al.*, 2008; Freitas *et al.*, 2019).

A native species to the Canary Islands, frequent on the predominant sandy bottoms of the eastern islands, but occasional on the predominant rocky ones of the western islands. It inhabits from 3 to 80 m depth (Brito *et al.*, 2002). Reported maximum size: to 36 cm TL and 0.670 kg (González *et al.*, 2012); common to 30 cm TL. Spanish vernacular names: vaquita; vaqueta; cabrilla pintada. It is a secondary fishery resource exploited all year round by local small-scale fisheries with hook-and-line, traps and trammel nets (González *et al.*, 2020). Its landings showed no notable trend over the period of 2014–2019, yielding a mean value near 5.9 t/y, with a peak of 13.7 t in 2018. This resource is also subject to some recreational fishing activity.

Its English common name proposed by Vella *et al.* (2021) is intended to derive from the original name (“le serran papilionacé”) used by Valenciennes, since the species exhibits a striking chromatic feature: “les nageoires impaires sont rougeâtres avec des linéaments ou des ocelles violets, simulant des taches que l’on rencontre sur les ailes des papillons de nuit”. Therefore, in correct English it should be “moth-

winged” comber, given the clear difference between “butterfly” (diurnal) and “moth” (nocturnal).

Subfamily Anthiadinae

***Anthias anthias* (Linnaeus, 1758)** – Swallowtail seaperch

Serranus anthias: Valenciennes, 1842: 8 (L).

Anthias sacer: Steindachner, 1865: 399 (T), 1867: 608-609 (T), 1891: 355 (GC, T); Vinciguerra, 1890: 469 (GC), 1893: 303 (GC, T).

Anthias anthias: Fowler, 1936: 774-776 (GC, L, T); Doo-ley *et al.*, 1985: 16 (T, L, GC); Pizarro, 1985: 170 (F); Brito, 1991: 94, 111 (C); González-Jiménez *et al.*, 1994: 86-87 (C); Franquet and Brito, 1995: 93 (C); Brito *et al.*, 2002: 215, 229 (C); Báez *et al.*, 2019: suppl. tab. (C); Freitas *et al.*, 2019: suppl. tab. S3 (C).

An eastern Atlantic warm-temperate species, also known from the Mediterranean and, in the East Atlantic, from Galicia (Bañón *et al.*, 2020) and Portugal to Morocco (Collignon, 1973 – frequent) and southwards to Angola and northern Namibia, including the Azores, Madeira, Selvagens, Canary and Cabo Verde Islands (Heemstra and Anderson, 2016; Freitas *et al.*, 2019; Froese and Pauly, 2020).

It is a common species native to the Canary Islands, inhabiting from 30 to 300 m depth (Brito *et al.*, 2002). Reported maximum size: to 25 cm SL; common to 13 cm SL. Spanish vernacular names: fula amarilla; andoriña. It is part of the bycatch in the domestic small-scale commercial and recreational fishing, rarely commercialized or seen in fish markets.

Subfamily Epinephelinae

***Cephalopholis nigri* (Günther, 1859)** – Niger hind

Cephalopholis nigri: Brito, 1991: 103 (T); Brito *et al.*, 2002: 216, 230 (T); Falcón *et al.*, 2018: 43, 55 (GC); Báez *et al.*, 2019: suppl. tab. (C).

A tropical and subtropical species, known from Senegal and Ghana (Cadenat, 1935) to Lobito, Angola, including São Tomé and Príncipe Islands (Heemstra and Anderson, 2016; Froese and Pauly, 2020); absent from the Azores, Madeira, Selvagens, Canary and Cabo Verde Islands (Freitas *et al.*, 2019).

A very rare species in the Canary Islands, where it was first recorded in 1988 based on a juvenile collected at 8-10 m depth (Brito, 1991) and newly recorded in 2018 based on an adult photographed at 25 m depth (Falcón *et al.*, 2018). Reported maximum size: to 25 cm TL.

***Cephalopholis taeniops* (Valenciennes, 1828)** – African hind or blue-spotted seabass

Cephalopholis taeniops: Brito *et al.*, 2011: 2185-2189 (GC); Triay-Portella *et al.*, 2015: 165-166 (GC); Pajuelo *et al.*, 2016: 25-26 (GC); Falcón *et al.*, 2018: 43 (GC); Báez *et al.*, 2019: suppl. tab. (C).

A Guinean species, found from Atlantic Morocco to Angola, including the Canary and Cabo Verde Islands (Triay-Portella *et al.*, 2015; Heemstra and Anderson, 2016). After the first record of this species for the Canaries in December 2009 based on a subadult (Brito *et al.*, 2011), *C. taeniops* is now regularly observed in the region and sometimes captured and commercialized.

It is a non-native species in the Canary Islands, inhabiting between 15 and 30 m depth. Reported maximum size: to 39 cm TL. Spanish vernacular names: mero tropical. It is part of the bycatch in local commercial and recreational fishing. When captured it is commercialized or consumed by the fishermen themselves.

***Epinephelus adscensionis* (Osbeck, 1765)** – Rock hind

Cephalopholis cf. cruentata: Falcón, 2015 (PhD Thesis).

Epinephelus adscensionis: Falcón *et al.*, 2018: 42, 55 (GC); Báez *et al.*, 2019: suppl. tab. (C) (as to be confirmed).

An amphi-Atlantic species with warm affinity; a wide-ranging species in the Atlantic (Craig *et al.*, 2011). Western Atlantic: from Massachusetts, USA and Bermuda to southern Brazil, including Vila dos Remedios, Abrolhos, Fernando de Noronha and Trindade islands. Central Atlantic: Bonaparte Seamount, and Ascension and St. Helena Islands. Eastern Atlantic: São Tomé and Príncipe (Craig *et al.*, 2011; Heemstra and Anderson, 2016; Froese and Pauly, 2020). Reports of this species from the Azores and Cabo Verde Islands (Freitas *et al.*, 2019), as well as from South Africa are unsubstantiated (Froese and Pauly, 2020).

It has been observed twice off the island of Gran Canaria with one individual each sighting (Falcón, 2015 as *Cephalopholis cf. cruentata*; Falcón *et al.*, 2018). Reported maximum size: to 45 cm TL.

***Epinephelus aeneus* (Geoffroy Saint-Hilaire, 1817)** – White grouper

An Atlanto-Mediterranean species; primarily distributed in the southern Mediterranean (Cadenat, 1935), southern Portugal and along the western coast of Africa from Morocco (Collignon, 1973 – south of Agadir, rare) and Western Sahara (Cadenat, 1935; Collignon, 1973 – very frequent) to southern Angola, including the islands in the Gulf of Guinea (Craig *et al.*, 2011; Heemstra and Anderson, 2016; Froese and Pauly, 2020). Absent from the Azores, Madeira, Selvagens, Canary and Cabo Verde Islands (Freitas *et al.*, 2019). Recently, it has penetrated into more northern latitudes both in the Atlantic and the Mediterranean: Corsica, France (Riutort, 2012), southern Bay of Biscay, NW Spain, 43°42'44"N (Bañón *et al.*, 2017) or its northernmost occurrence in the eastern Adriatic Sea, Croatian coast, 44°06'46.9"N (Dulčić *et al.*, 2006).

Material examined. – An adult, 895 mm TL (7.5 kg), off Punta del Socorro – Caletón de los Artillos, eastern Tenerife,



Figure 4. – First record of *Epinephelus aeneus* for the Canary Islands. Adult, 895 mm TL, 7.5 kg; off Punta del Socorro, Tenerife, 21 Oct. 2015 (Credits: L. Sabina, 2015).

28°19'42"N 16°21'06"W, 70 m depth, F/V *Kumbayah*, 21 Oct. 2015, bottom trap (Fig. 4). After photography, examination and identification, the fish was sold at the fish market, which prevented its preservation.

It is a non-native species to the Canary Islands; the present finding constitutes the first record of *E. aeneus* for the Canaries. Specimens of this species from the north-west-African coasts have been permanently present in the fish markets of the Canary Islands since the 15th century (Balguerías, 1993), where they are highly appreciated and consumed in traditional regional dishes. Spanish vernacular names: cherne; cherne blanco; cherne moruno.

***Epinephelus caninus* (Valenciennes, 1843)** – Dogtooth grouper

Serranus caninus: Valenciennes, 1843: 10 (type description) (C); Steindachner, 1865: 404 (T); Vinciguerra, 1893: 304 (T).

Epinephelus caninus: Cadenat, 1935: 398-399 (C); Doo-

ley *et al.*, 1985: 16 (C); Pizarro, 1985: 171 (F); Brito, 1991: 103 (F); Franquet and Brito, 1995: 66 (C); Brito *et al.*, 2002: 216, 230-231 (F, L); Báez *et al.*, 2019: suppl. tab. (C); Freitas *et al.*, 2019: suppl. tab. S3 (C).

An eastern Atlantic warm-temperate species, distributed along the Mediterranean Sea and, in the eastern Atlantic, from off Portugal and along the west coast of Africa from Morocco (Collignon, 1973 – rare) and Western Sahara (Cadenat, 1935 – frequent) to Angola, including the Mediterranean (Craig *et al.*, 2011) and Canary Islands; not known from the Cabo Verde Islands (Heemstra and Anderson, 2016; Freitas *et al.*, 2019; Froese and Pauly, 2020).

It is a very rare species in waters of the Canaries, and findings on the coasts (between 50 and 200 m depth) of the two easternmost islands – Fuerteventura and Lanzarote, the islands closest to the African continent – are possibly based on large vagrant individuals (Brito *et al.*, 2002). It was originally described by Valenciennes in the Canaries in 1843 based on type material probably caught off the north-western African coast (Brito *et al.*, 2002), and newly recorded in June 1978 based on two specimens from the western coast (off Ajuy) of Fuerteventura (Brito, 1991) and on three subsequent findings (data unknown) at Lanzarote (Brito *et al.*, 2002). In the last two decades, a few large specimens have been sporadically caught off these islands (first author's personal observation). Reported maximum size: up to 164 cm total length and 57 kg (Morales-Nin *et al.*, 2005), but attains at least 1.8 m and 75 kg (Heemstra and Anderson, 2016), and a maximum weight of 78 kg was reported from Spain (Francour and Pollard, 2018). Spanish vernacular names: cherne moruno; cherne de ley.

***Epinephelus costae* (Steindachner, 1878)** – Goldblotch grouper

Serranus acutirostris: Valenciennes, 1843: 11 (text), Atl. Pl. III, fig. 1 (GC); Steindachner, 1865: 399 (T); Vinciguerra, 1890: 470 (GC), 1893: 304 (GC).

Epinephelus alexandrinus: Steindachner, 1898: 789 (C); Dooley *et al.*, 1985: 16 (T); Brito, 1991: 103, 111 (GR, T).

Epinephelus ruber: Cadenat 1935: 393-395 (C).

Epinephelus costae: Franquet and Brito, 1995: 66 (C); Brito *et al.*, 2002: 216, 232 (C); Craig *et al.*, 2011: 120 (C); Triay-Portella *et al.*, 2015: 164 (GC); Báez *et al.*, 2019: suppl. tab. (C); Freitas *et al.*, 2019: suppl. tab. S3 (C).

An eastern Atlantic warm-temperate species distributed along the Mediterranean Sea, and on the eastern Atlantic coasts from off Portugal and Morocco (Collignon, 1973 – rare) to central Angola, including the Canary and Cabo Verde Islands (Craig *et al.*, 2011; Heemstra and Anderson, 2016; Freitas *et al.*, 2019; Froese and Pauly, 2020). Recently recorded from its northernmost (42°15.007'N) range expansion, *i.e.* Galician waters (Bañón *et al.*, 2018).



Figure 5. – *Epinephelus costae* from Fuerteventura, Canary Islands (Credits: R. García, 2019).



Figure 6. – *Epinephelus costae* from La Gomera, Canary Islands (Credits: J. Carballo, 2019).

Sightings. – A juvenile was observed and photographed by P. Pascual (IEO) in 1995 off Punta del Vidrio, southern Tenerife, 28°04'N 16°30'W, at 8 m depth. Another juvenile was photographed by R. Martel (an experienced scuba diver) in 1997 off La Caleta, north-eastern El Hierro, 27°47'N 17°53'W, at 10 m depth. Another juvenile was observed by the first author in 1999 off Punta Teno, north-western Tenerife, 28°11'N 16°55'W, at 12 m depth. According to recent communications by spear fishermen in the area, a permanent aggregation of *E. costae* individuals, constituted of both juvenile and adult fish up to 94 cm TL (8 kg), appears to be well established since 2012 on the south-western coast of Fuerteventura, between Punta Pesebre and Punta Jandía, and spilling over to Cofete on the windward coast, at 20-40 m depth. This Canarian population has been regularly exploit-

ed, year-by-year, by recreational fishing (Fig. 5) and, to a lesser extent, with sporadic captures by artisanal fisheries. Posteriorly, the third author identified five specimens from the professional fishing in the north-eastern coast of Gran Canaria, and one more caught in the archipelago in a fish market on Lanzarote in November of 2019. In addition, an adult (85 cm TL, 6 kg) was spearfished in January of 2019 off Alojera, north-western La Gomera, 28°09'N 17°20'W, at 31 m depth (Fig. 6). At last, in November of 2019, a juvenile appeared in an awarded photograph at the 'Open Fotosub El Hierro' competition, at La Restinga, southern El Hierro – the westernmost island in the Canary archipelago.

Records of this species in the Canaries by Brito (1991) were based on juveniles (five single findings in total) caught off Lanzarote and Tenerife at 8-20 m depth. Reported maximum size: to 94 cm TL (about 8 kg). Spanish vernacular names: abadejo; mero liso.

***Epinephelus fasciatus* (Forsskål, 1775)** – Blacktip grouper
Epinephelus fasciatus: Falcón *et al.*, 2018: 41-42, 55 (GC).

Epinephelus fasciatus: Báez *et al.*, 2019: suppl. tab. (C) (as to be confirmed).

An Indo-Pacific warm-affinity species, ranging from the Red Sea to Port Alfred, South Africa in the west, and throughout the western and central Pacific (Craig *et al.*, 2011; Froese and Pauly, 2020).

It is a single-record non-native species in the Canaries, from where it has been recently first recorded based on a 30 cm TL adult caught in June 2018 close to the Port of Las Palmas, Gran Canaria (Falcón *et al.*, 2018).

***Epinephelus itajara* (Lichtenstein, 1822)** – Atlantic goliath grouper

Epinephelus (Promicrops) esonue: Brito, 1991: 103 (T, GR).

Epinephelus itajara: Brito *et al.*, 2002: 216 (T); Báez *et al.*, 2019: suppl. tab. (C); Freitas *et al.*, 2019: suppl. tab. S3 (C).

An amphi-Atlantic warm-affinity species. In the western Atlantic: from Florida to southern Brazil. In the eastern Atlantic: known from the Canary Islands (rare) and Senegal to Angola (Heemstra and Anderson, 2016; Freitas *et al.*, 2019; Froese and Pauly, 2020). Eastern Pacific (Gulf of California to Peru) species is now recognized as *Epinephelus quinquefasciatus* (Bocourt, 1868) (Heemstra and Randall, 1993; Froese and Pauly, 2020).

A very rare species in waters of the Canaries, where it was first recorded by Brito (1991). Its presence in the region was confirmed by Brito *et al.* (2002), based on two single captures and one sighting of "very big individuals" off Tenerife, between 15 and 49 m depth. Spanish vernacular names: mero negro, guasa.

***Epinephelus marginatus* (Lowe, 1834)** – Dusky grouper

Serranus fimbriatus: Valenciennes, 1843: 8 (C).

Serranus gigas: Steindachner, 1867: 613-615 (T); Vinciguerra, 1883: 609 (T), 1893: 303-304 (T).

Gadus monoapterigiis cirratus: Viera y Clavijo, 1868 (1982): 282 (C).

Epinephelus gigas: Cadenat, 1935: 400 (in synonyms).

Serranus guaza: Fowler, 1936: 760-762 (C).

Epinephelus guaza: Jordan and Gunn, 1899: 341 (C); Dooley *et al.*, 1985: 16 (C); Pizarro, 1985: 85 (F); Brito, 1991: 103, 112 (C); González-Jiménez *et al.*, 1994: 78-79 (C).

Epinephelus marginatus: Franquet and Brito, 1995: 66 (C); Brito *et al.*, 2002: 216, 232 (C); González *et al.*, 2012: 144-145 (C); Báez *et al.*, 2019: suppl. tab. (C); Freitas *et al.*, 2019: suppl. tab. S3 (C).

An amphi-Atlantic and western Indian Ocean species with warm affinity. Western Indian Ocean: from southern Mozambique and Madagascar to South Africa, and recently recorded from Réunion Island (vagrant) (Reid *et al.*, 2016) and Arabian Sea (Oman), but absent from surrounding areas (Béarez *et al.*, 2020). Western Atlantic: from southern Brazil to Argentina. Eastern Atlantic: throughout the Mediterranean Sea and from the northern Bay of Biscay (Brittany) to Morocco (Collignon, 1973 – frequent) and southwards to Angola, including the Azores, Madeira, Selvagens, Canary and Cabo Verde Islands; stray specimens reported from the British Isles, and eastern English Channel (Normandy, France) (Heemstra and Anderson, 2016; Freitas *et al.*, 2019; Froese and Pauly, 2020).

It is a common species native to the Canary Islands, living between the coastline and 200 m of depth; juveniles frequently inhabit intertidal pools (Brito, 1991; Brito *et al.*, 2002; González *et al.*, 2020). Reported maximum size: to 160 cm TL and 60 kg (González *et al.*, 2012). Spanish vernacular names: mero. In the region, it is an important fishery resource exploited all year round by domestic small-scale fisheries with hook-and-line, traps, and trammel nets. Its landings seem to be stabilized around a mean of 33.3 t/y in the period of 2014-2019, with a peak of 37.3 t in 2017 (González *et al.*, 2020). It is also subject to some recreational fishing activity (González *et al.*, 2012).

***Mycteroperca fusca* (Lowe, 1838)** – Island grouper

Serranus fuscus: Valenciennes, 1843: 8 (GC); Steindachner, 1867: 616-617 (T).

Serranus emarginatus: Valenciennes, 1843: 10 (C); Steindachner, 1865: 399 (T).

Mycteroperca rubra: Fowler, 1936: 762-764 (C); Dooley *et al.*, 1985: 16 (GC, LG, EH, T); Pizarro, 1985: 86 (F); Brito, 1991: 103-104, 112-113 (C); González-Jiménez *et al.*, 1994: 80-82 (C).

Mycteroperca fusca: Franquet and Brito, 1995: 66 (C); Brito *et al.*, 2002: 216, 233-234 (C); González *et al.*, 2012: 146-147 (C); Báez *et al.*, 2019: suppl. tab. (C); Freitas *et al.*, 2019: suppl. tab. S3 (C).

An insular species endemic to the north-eastern Atlantic archipelagos – *i.e.* the Azores, Madeira, Selvagens, Canary and Cabo Verde Islands (Heemstra and Anderson, 2016; Freitas *et al.*, 2019; Froese and Pauly, 2020).

It is a common species in waters of the Canaries. Reported maximum size: to 80 cm TL and 9 kg (González *et al.*, 2012). Spanish vernacular names: abade, abade del país. In the Canaries, it is an important fishery resource exploited all year round by local artisanal fisheries with hook-and-line, traps, and trammel nets. Its landings seem to have stabilized around a mean of 14.6 t/y in the period of 2014-2019, with a peak of 19.4 t in 2016 (González *et al.*, 2020). It is also targeted by some recreational fishing activity (González *et al.*, 2012).

***Mycteroperca tigris* (Valenciennes, 1833)** – Tiger grouper

Mycteroperca tigris: Falcón *et al.*, 2018: 41, 55 (GC); Báez *et al.*, 2019: suppl. tab. (C) (as to be confirmed).

A western Atlantic warm-affinity species, occurring from southern Florida and Flower Garden Banks off Texas, the Gulf of Mexico, the Bahamas, Cuba, Haiti, Jamaica, Venezuela, and throughout the Caribbean to Brazil (Craig *et al.*, 2011; Froese and Pauly, 2020).

It is a very rare non-native species in the Canary Islands, recently first recorded there based on a 50 cm TL adult caught at the Port of Las Palmas, Gran Canaria in February 2018 (Falcón *et al.*, 2018). However, the record of this species in the Canaries should be considered, for now, as doubtful (see Discussion).

***Paranthias furcifer* (Valenciennes, 1828)** – Creole fish

Paranthias furcifer: Triay-Portella *et al.*, 2015: 165-166 (GC); Báez *et al.*, 2019: suppl. tab. (C).

Although primarily a western Atlantic species, it should now be considered as an amphi-Atlantic warm-affinity species (Triay-Portella *et al.*, 2015). In the eastern Atlantic it is reported from Ascension Island and Bay of Biafra (Príncipe, São Tomé, and Annobon Islands) (Parenti and Randall, 2020).

It is a rare non-native species in the Canary Islands, being sighted by the authors five times on NE and E coasts of Gran Canaria between 6 and 21 m depth. It was first recorded by Triay-Portella *et al.* (2015), based on several individuals caught in April and May of 2015. Since then, only one more adult individual – caught on the north-eastern coast of Gran Canaria on the seaways to its two main ports – was reported to us in 2019 by recreational fishers. Reported maximum size: to 36 cm TL.

DISCUSSION

Considering the first documented records of *Serranus hepatus* and *Epinephelus aeneus* presented here, the inventory of the Serranidae occurring in Canary Islands waters initially comprises seventeen species.

However, the record of *Mycteroperca tigris* in the Canaries has to be considered dubious. The colour pattern of the original photo in Falcón *et al.* (2018: 55, fig. 1A) does not completely agree with the species description. For example, the oblique pale stripes are not visible in the mentioned photo (adults with pale rivulations, according to Heemstra and Randall, 1993: 277, and Craig *et al.*, 2011: 321). Given that it is a western Atlantic species, only a detailed morphological and/or molecular examination of specimens could confirm the presence of this species in the eastern Atlantic.

The biogeographic pattern, temporal process of establishment, local fishing uses, and measures implemented for their conservation management are summarized in table I. Only four species have been biologically studied in the region (see García-Díaz *et al.*, 1997, 2006; Tuset *et al.*, 2005; Bustos *et al.*, 2010) and their basic parameters are available to support the implementation/updating of fisheries management measures, at least for the establishment of a legal minimum landing size (MLS) (Tab. I). A scientific-based proposal of MLSs for *S. atricauda*, *S. cabrilla*, *S. papilionaceus* (as *S. scriba*) and *M. fusca* was compiled by González *et al.* (2012). Therefore, more specific biological studies are needed to support the sustainable management of regional fishery resources as important as the native population of *E. marginatus* or the newly established and expanding *E. costae*. Major threats to groupers (Epinephelinae) are habitat loss, overfishing and the lack of effective management (Craig *et al.*, 2011).

Seven of these serranid species are well established in the region with regular catches or landings: *S. atricauda*, *S. cabrilla*, *S. papilionaceus*, *Anthias anthias*, *E. costae*, *E. marginatus*, and *M. fusca*. In addition, an eighth species, *S. hepatus*, seems to be in the process of establishment in the waters of the Canary Islands, since fish-traps simultaneously catch specimens of various sizes, sometimes mixed together with other congeneric species, both at locations on the courses of oil rigs towards large ports and also far from them.

The resurrection of *S. papilionaceus* as a valid species in the region calls for new research to better understand its geographical distribution, threats and conservation management, and similarly its sister species *S. scriba* (Vella *et al.*, 2021). When *S. scriba* was thought to be an Atlanto-Mediterranean species, its absence in Cabo Verde, Madeira, Selvagens and Azores (Wirtz *et al.*, 2008; Afonso *et al.*, 2013; Freitas *et al.*, 2019) was already difficult to explain within the scope of such a biogeographic pattern. Now, the known geographic distribution of *S. papilionaceus* is clearly compatible with the biogeographic pattern of the tropical-sub-

tropical species of the eastern Atlantic (*i.e.* Guinean species), which usually have their northern limit at the latitude of Morocco and the Canary Islands.

According to their biogeographic pattern, five out of the 16 certainly recorded serranids have an eastern-Atlantic warm-temperate distribution (*S. atricauda*, *S. cabrilla*, *A. anthias*, *E. caninus*, and *E. costae*), two are Atlanto-Mediterranean species (*S. hepatus*, and *E. aeneus*), three are tropical and subtropical species (*S. papilionaceus*, *Cephalopholis nigri*, and *C. taeniops*), three are amphi-Atlantic species with warm affinity (*E. adscensionis*, *E. itajara*, and *Paranthias furcifer*), one has an amphi-Atlantic and western Indian Ocean distribution (*E. marginatus*), one is endemic to the north-eastern Atlantic archipelagos (*M. fusca*), and another is an Indo-Pacific species with warm affinity (*E. fasciatus*). The predominance of warm affinity species is in accordance with the current scenario of regional tropicalization of fish assemblages in temperate biogeographic transition zones, including Macaronesia (Afonso *et al.*, 2013; Horta Costa *et al.*, 2014), probably associated with global warming (Perry *et al.*, 2005; Occhipinti-Ambrogi, 2007).

In this regard, climate change is favouring the displacement of some populations of marine fishes towards latitudes further north and their gradual replacement by other exotic species from nearby subtropical and tropical areas (Vergés *et al.*, 2014; Wernberg *et al.*, 2016). The human-mediated introduction and subsequent spread of exotic species are considered one of the main threats to marine biodiversity (Lockett and Gomon, 2001; Molnar *et al.*, 2008).

Serranus hepatus appears as known from the Canaries in several publications (see the Annotated List section), but those records are unsubstantiated (Brito *et al.*, 2002; Heemstra and Anderson, 2016; present work). Therefore, the present record is the first objective record from the Canary Islands waters, in the absence of any other specimens housed in museum collections, as far as we know. Moreover, this species is herein recorded for the first time for Webbenesia marine ecoregion (*sensu* Freitas *et al.*, 2019) and for Macaronesia marine ecoregion (*sensu* Spalding *et al.*, 2007). Regarding the arrival and establishment status of *S. hepatus* in waters of the Canary Islands, two viable hypotheses can be proposed in the light of the evidence gathered herein. The first is based on a natural range extension (*i.e.* a natural population expansion) as a result of high oceanographic connectivity (trade winds, marine currents and larval flow) between the neighbouring north-western African coasts and this archipelago (Barton *et al.*, 1998; Landeira *et al.*, 2010). The second hypothesis is human-caused introduction, either from ship ballast water containing larval stages that have dispersed into the wild (Wonham *et al.*, 2000; Brito *et al.*, 2011; Galil *et al.*, 2011), or transport of juveniles, subadults or/and adults on oil platforms (Friedlander *et al.*, 2014; Triay-Portella *et al.*, 2015; Pajuelo *et al.*, 2016). Another

Table I. – Species of Serranidae occurring around the Canary Islands. Biogeographic pattern, temporal process of establishment, local fishing uses, and measures for their conservation management. EAWT: eastern Atlantic warm-temperate species; ATLTM: Atlanto-Mediterranean species; TSEA: tropical and subtropical eastern Atlantic species (Guinean species); AAWA: ampho-Atlantic species with warm affinity; IPWA: Indo-Pacific species with warm affinity; AAWIO: ampho-Atlantic and western Indian Ocean species with warm affinity; EMsl: endemic to Macaronesia *sensu lato* (from the Azores to Cabo Verde Islands); WAWA: western Atlantic species with warm affinity. Numbers in columns of records represent year of capture or sighting. MLS: Minimum landing size.

Canary Islands Serranidae	Biogeographic pattern	Establishment			Local fishing uses	Conservation management		
		Appearance	New records	Established		In force	Proposed	Main reference
<i>S. atricauda</i>	EAWT	1859	1874 - to date	Yes	Commercial, gamefish	MLS 15 cm TL	19 cm TL	García-Díaz <i>et al.</i> , 2006
<i>S. cabrilla</i>	EAWT	1842	1865 - to date	Yes	Commercial, gamefish	MLS 15-19 cm TL	17 cm TL	García-Díaz <i>et al.</i> , 1997
<i>S. hepattus</i>	ATLM	(1936) 2020	2020 - to date	Ongoing	None	Not evaluated		
<i>S. papilionaceus</i>	TSEA	1842	1890 - to date	Yes	Commercial, gamefish	None	17 cm TL	Tuset <i>et al.</i> , 2005
<i>A. anthias</i>	EAWT	1842	1865 - to date	Yes	Minor	Not evaluated		
<i>C. nigri</i>	TSEA	1988	1991-2018	Insufficient data	Not evaluated	Not evaluated		
<i>C. taeniops</i>	TSEA	2009 (2011)	2015 - to date	Insufficient data	Minor	Not evaluated		
<i>E. adscensionis</i>	AAWA	2012	None	Not	Not evaluated	Not evaluated		
<i>E. aeneus</i>	ATLM	2015 (this work)	None	Not	Not evaluated	Not evaluated		
<i>E. caninus</i>	EAWT	1843 (1978)	2000 approx.	Not	Not evaluated	Not evaluated		
<i>E. costae</i>	EAWT	1843	1865 - to date	Yes (on 1 island)	Minor, gamefish	Not evaluated		
<i>E. fasciatus</i>	IPWA	2018	None	Not	Not evaluated	Not evaluated		
<i>E. itajara</i>	AAWA	1990 approx.	None	Not	Minor, gamefish	MLS 45 cm TL	No data	
<i>E. marginatus</i>	AAWIO	1843	1867 - to date	Yes	Commercial, gamefish	Not evaluated		
<i>M. fusca</i>	EMsl	1843	1865 - to date	Yes	Commercial, gamefish	MLS 35 cm TL	35 cm TL	Bustos <i>et al.</i> , 2010
<i>M. tigris</i> ?	WAWA	2018 (doubtful)	None	Not	Not evaluated	Not evaluated		
<i>P. furcifer</i>	AAWA	2015	2019	Not	Not evaluated	Not evaluated		

third hypothesis could be based on an unrecorded ancestral presence, due to being naturally uncommon or confused with juveniles of other species; this should be discarded faced with the currently available data.

Epinephelus aeneus is also herein first recorded from the Canary Islands waters. Its absence from the Canaries (and even Madeira) was puzzling (Heemstra and Anderson, 2016). Along the eastern Atlantic coasts, this species has recently penetrated into the southern Bay of Biscay, off north-western Spain (Bañón *et al.*, 2017). The finding of a single individual of this species in Canary waters is insufficient support for speculation on whether it was an old vagrant or straying specimen or an attempt to establish itself in this archipelago.

Sightings in Canary waters of juveniles of *E. costae* since 1990, establishment of a population of this species on the island closest to the African continent (Fuerteventura) since at least 2012, and the subsequent occurrences of its juveniles and adults in practically all the islands of the archipelago are all proven facts. Its northernmost Atlantic limit has been set at the latitudes of Galicia and southern Bay of Biscay, and the recent expansion of some *Epinephelus* species, such as *E. aeneus* and *E. costae* (*e.g.* Bañón *et al.*, 2018), is the result of the above-mentioned warming process of these waters. In addition, as suggested for *E. marginatus* from the Arabian Sea coast off Oman (Béarez *et al.*, 2020), the restricted occurrence of a population of *E. costae* off the southern coast of the island of Fuerteventura may be attributable to a seasonal coastal upwelling.

The most plausible possibility explaining the occurrence of primarily western Atlantic, tropical/subtropical eastern Atlantic, and also Indo-Pacific serranid species in waters of the Canary Islands would be the transport of juvenile, subadult or/and adult fish specimen on oil platforms (or even via ballast water of ships). Their individuals are generally observed and/or captured in the vicinity of the main ports or in the pathways to these ports with heavy over-seas traffic. A natural expansion tropical and subtropical African species would be also possible (Triay-Portella *et al.*, 2015; Pajuelo *et al.*, 2016; Falcón *et al.*, 2018).

Further genetic research on populations of these large groupers is needed to better clarify their disjunct geographical distribution, the timing of colonization and their connectivity on a global scale (Béarez *et al.*, 2020). Groupers (*Epinephe-*

linae) are top predator fishes in marine food chains and are also among the largest fishes in coastal ecosystems. Therefore, changes in their distribution, abundance, and colonization abilities as exotic species may have a significant influence on native communities (Glamuzina, 1999). As pointed out by Triay-Portella *et al.* (2015) and Pajuelo *et al.* (2016), it would be necessary and urgent to implement control and monitoring measures on these species.

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